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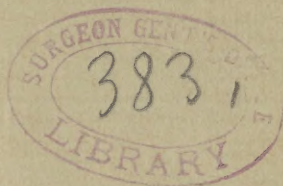
THE ARTIFICIAL FEEDING OF INFANTS.

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THE ARTIFICIAL FEEDING OF INFANTS.*

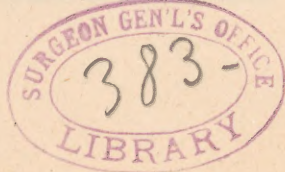
BY T. M. ROTCH, M.D.,

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in the Harvard Medical School.

WHILE recognizing the importance of feeding infants during the early months of life by means of human milk, we must allow that in civilized communities the necessity of supplying the infant with food not directly from the human breast must often arise, and will in all probability be a demand which will increase rather than decrease as our civilization advances; and when in addition to this we consider the great proportionate mortality of the artificially-fed over the breast-fed, and the difficulties which are so frequently met with in adapting the food to the individual case, it manifestly becomes a duty to carefully investigate the different methods of artificial feeding, and adopt some more uniform plan for starting human beings in life than is met with among physicians as a class and the laity as a whole, for diversity and not uniformity is the rule.

With the exception of the very small proportionate per cent. of inherited diseases which occur at birth, this diversity of method in feeding is the most prolific source of disease in early infancy. The group of symptoms which for want of a better name is represented by dyspepsia, difficult digestion, occurs most frequently in the three periods when the infant's digestion is likely to be tampered with,—namely, in the early weeks of life, when experiments are being made to determine what food will be best to start with; next, when in addition to the irritation arising from the beginning of dentition new articles of diet are added to the original food; and, thirdly, at

* Read before the Obstetrical Society of Boston, May 28, 1887.



the time of weaning, when there is often a sudden and entire change in the character of the food.

The proper management of the first of these periods is of the greatest comparative importance, because it is the time when the function of digestion is being established and is in a state of unstable equilibrium, and therefore, following the rule of functional establishment, the stomach is in its most active period of growth, and hence the most careful regulation of the bulk of the food given is needed to correspond to this activity in order that we should not weaken the digestive function by overtaxing its capacity and yet provide the proper materials for nutrition, thus avoiding by prophylaxis the dyspepsia of the later periods of infancy and childhood, the seeds of which are continually being sown in this early transitional period.

We therefore have the question not only of infantile digestion but infantile development to deal with, and we should at once recognize the fact that the problem of artificial feeding is not a simple factor,—namely, which food shall we give to the infant,—but is a combination of factors, of which the kind of food is only one, and all these factors, from which we deduce the general problem for the average infant and the especial problem for the individual, must approach as closely as possible to the analogous factors which nature freely presents to us for investigation,—that is, we must follow nature as closely as possible. Our scientific knowledge and ingenuity have not yet enabled us to follow nature exactly, and we therefore have not yet obtained an ideal method of artificial feeding; but we must, nevertheless, go as far as the present state of our knowledge will allow, thus gaining a little ground every year; and we must be especially careful not to be led astray by the fictitiously brilliant results which are reported from time to time in favor of certain foods, instances continually occurring where one food will fail and another when substituted for it succeed; and yet these successes are merely temporary, and the mortality always remains far above that of human breast-milk.

It is certainly wiser and more economical not to spare expense and trouble in arranging the infant's diet, for, as has been explained above, the period of active growth of an organ

is the time when its function is readily weakened, and when once weakened the digestive function is a prolific source of annoyance and expense in childhood and adolescence. Cheap foods and cheap methods of feeding, unless they are the best that can be procured, should no more be tolerated, and in fact not nearly so much so, in the early feeding of infants than in adult life: we often, however, see a food recommended for a young infant because it is cheap and easily prepared, and yet where its well-known lack of nutritive ingredients would with adults at once stamp it as unfit for use.

What are the general factors of the problem which constitutes nature's method of feeding? We have first a receptacle, the human breast, which mechanically provides a fresh supply of food at proper intervals, absolutely prevents fermentation of the food before it enters the infant's mouth, forms the mouth by the process of sucking, incites to action the necessary digestive fluids, avoids a vacuum by collapsing as it is gradually emptied, thus allowing the food to flow continuously, and finally is practically self-regulating as to the amount of daily food according to the infant's age. Second, the food itself adapted to the infant's digestive function and for its development, by its temperature, 98° to 100° F., its alkaline reaction, and its chemical constituents. Given these factors, how nearly can we approach them artificially? Human ingenuity has not yet been able to devise anything which approaches the perfection of nature's receptacle, and the best that we can do to offset this complex mechanism is to adopt that which is exactly the reverse,—namely, a receptacle of absolute simplicity,—and thus combat the tendency to fermentation by, through perfect cleanliness, preventing the receptacle from becoming a source of fermentation. To meet this demand I have had made what are practically enlarged test-tubes, which not having any angles are readily cleaned.

The receptacle, however, has to receive a food which usually is non-sterilized, and hence, where the factor of fermentation appears to be prominent in disturbing the infant's digestion, the food should be sterilized before it is given to the infant.

The process of sterilization is most simply accomplished by placing the food in one of the above spoken of feeding-tubes,

adjusting the rubber nipple as on any nursing-bottle, then drawing tightly over the nipple and well down on to the tube a strong rubber cot, which, not being perforated, completely excludes the air. The tube is then exposed to steam confined in any vessel for twenty minutes, which is sufficient to render it sterile, in the sense of destroying the developed bacteria and thus making it correspond to human milk; at the same time, so far as my investigations on this subject have gone, the steam, while it sterilizes, does not apparently alter the chemical attributes of the food, as is essentially the case where the sterilization is accomplished by boiling; then again, in the steaming process the receptacle is sterilized as well as the food, so that when the rubber cot is removed we have the food enter the infant's mouth as free from bacteria as has been shown to be the case with human milk by Esherich,* who experimented with the milk of twenty-five healthy women, and found, by keeping it in sterilized tubes, that it remained sterile for some weeks, while, on the contrary, in women whose temperature was raised from fissures and excoriations of the nipple and by general puerperal infection, bacteria were found in abundance. It is thus seen that this factor of sterilization is likely to be found of considerable importance in the future, and should certainly be called to our aid in those cases where the other factors of our problem are as nearly correct as we can make them, and, if for no other reason, because nature plainly tells us that a perfect food should be sterile, and, in fact, our practical clinical experience for years has taught us to withdraw the infant from the breast in exactly that class of diseases where we now know bacteria to occur in the milk. Reference has been made above to the developed bacteria; if it is desired to prepare the food so that it shall remain sterile for some time, it is necessary to sterilize for several days in succession, for the first sterilization, according to Dr. Harold Ernst, Demonstrator of Bacteriology in the Harvard Medical School, only destroys these developed bacteria, while the spores are left to develop later. Dr. Ernst also kindly placed one of my tubes in which there was a mixture of cream, milk, lime-

* Baumgarten's Jahresbericht. Erster Jahrgang, 1885, p. 34.

water, and milk sugar in his sterilizer for twenty minutes and then in his incubator for twenty-four hours, and at the end of this time no change could be detected in the mixture, either in color, odor, or taste, all of which appeared to exactly correspond to a freshly prepared mixture of the same kind.

I have devised a simple apparatus for household use, which can be made at any tinsmith's at small expense, and answers for the purpose of sterilization very well.

It is a round tin pail, eight inches in diameter and fourteen inches deep, raised on three legs, sufficiently high to allow an alcohol lamp to stand under it; four inches from the bottom of the pail on the inside is a perforated tin diaphragm on which the feeding-tubes stand while being sterilized.

The pail has a cover and handle. Water is placed in the bottom of the pail, and when heated by the lamp the tubes are soon enveloped in steam.

The process of sucking is accomplished by the rubber nipple as by the breast, and a small hole near the end of the feeding-tube prevents a vacuum being formed and regulates the rapidity of the flow, while it allows it to be continuous; this is done by rolling up the edge of the rubber nipple from the hole with the finger, or letting it cover the hole according to the demand shown by the infant when feeding.

The artificial receptacle is not self-regulating, and hence we must first determine anatomically the amount of food in bulk which nature provides for the average infant at different ages, and from these average figures deduce the proper amount for the especial infant, having also the feeding-tubes graduated for the more important periods of growth, for the purpose of continually impressing, upon the mother and nurse, what the physician only has the opportunity of telling them at the beginning of the nursing period,—namely, that the error is in giving too much food rather than too little, an error also which naturally results when, as is commonly the case, the usual eight-ounce nursing-bottle is provided as the receptacle at the very beginning of infantile life.

Diagram I. represents the stomach of an infant five days old, in life-size.

The specimen was prepared by Dr. C. W. Townsend, and was found to hold twenty-five cubic centimetres.

DIAGRAM I.

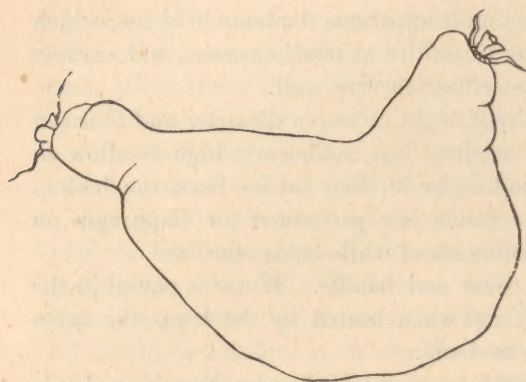


DIAGRAM II.

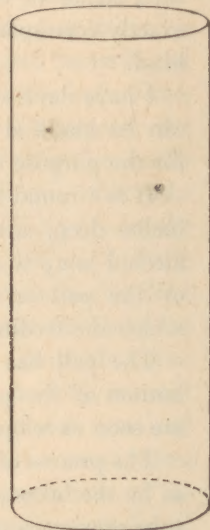


Diagram II. represents the size of the tube, which is sufficiently large for each feeding during the first week; and when we consider the space which would be needed to represent the full-sized nursing-bottle, these two diagrams express better than can be explained by words the disproportion between the size of the infant's stomach and the amount which the mother supposes it should hold to keep her child from being starved.

Frolowsky's* investigations show that the activity of growth in the stomach's capacity can be represented by the ratio of one for the first week, to two and one-half for the fourth week, and three and one-fifth for the eighth week, while it is only three and one-third for the twelfth week, three and four-sevenths for the sixteenth week, and three and three-fifths for the twentieth week.

We thus see that there is a very rapid increase in capacity in the first two months of life, while in the third, fourth, and

* Inauguraldiss., St. Petersburg, 1876.

fifth months the increase is slight. Guided by these data, which we find correspond closely with the results of clinical investigations bearing on this point, we should rapidly increase the quantity of the food in the first six or eight weeks, and then give the same quantity up to the fifth or sixth month, unless the infant's appetite evidently demands more, when of course a gradual increase should be made. A considerable increase in the quantity needed, also, usually takes place between the sixth and tenth month.

Ssnitkin, after a series of careful investigations in the Children's Hospital at St. Petersburg to determine the amount which should be given in the first thirty days of life, finds that the greater the weight the greater is the gastric capacity. His general results also show that one one-hundredth of the initial weight should be taken as the starting figure, and to this should be added one gramme to each day of life. This, for example, gives the following amounts for each feeding, which closely correspond to the average figures which I have computed and introduced in Table I. on the basis of three thousand grammes as the initial weight. Thus, one one-hundredth of three thousand would be thirty grammes for the early days, and at thirty days the amount given would be $30 + 30 = 60$ grammes, about two ounces.

The younger the infant the greater the metabolic activity, and hence the greater need for frequent feeding, for nutriment is required not only for the excess of waste but also for the rapid proportionate growth; this makes the intervals of feeding a factor of considerable importance in the management of the infant's diet.

The figures in Table I. are merely approximate average computations taken from the results of a number of Russian, German, and American observers and from my own experience during the past ten years, and are only intended to be a guide for the physician in his management of cases of difficult digestion, for of course some infants will have a greater appetite and a greater power for digestion than others of the same age and weight.

Table I.

The average initial weight of infants is 3000-4000 grammes = about 6-8 pounds.
 The average normal gain per day in the first 5 months is 20-30 grammes = about 1 ounce.

General Rules for Feeding.

Age.	Intervals of Feeding.	Number of Feedings in 24 Hours.	Average Amount at each Feeding.	Average Amount in 24 Hours.
1st week .	2 hours.	10	1 ounce.	10 ounces.
1-6 weeks .	2½ hours.	8	1½ to 2 ounces.	12 to 16 ounces.
6-12 weeks, and possibly to 5th or 6th month . .	3 hours.	6	3 to 4 ounces.	18 to 24 ounces.
At 6 mos. .	3 hours.	6	6 ounces.	36 ounces.
At 10 mos. .	3 hours.	5	8 ounces.	40 ounces.

The weight, as well as the age, is necessary to determine the amount for each feeding in the individual infant, the rule being $\frac{1}{100}$ of the initial weight + 1 gramme for each day during the first month.

Illustrations of above rule to serve as guides for especially difficult cases.				
Initial Weight.	Each Feeding.			
	Early Days.	At 15 Days.	At 30 Days.	
3000 grammes.	30 grammes (about §1).	30 + 15 = 45 grammes (about §1½).	30 + 30 = 60 grammes (about §2).	
4500 grammes.	45 grammes (about §1½).	45 + 15 = 60 grammes (about §2).	45 + 30 = 75 grammes (about §2½).	
6000 grammes.	60 grammes (about §2).	60 + 15 = 75 grammes (about §2½).	60 + 30 = 90 grammes (about §3).	

I have experimented with the glass-blower in having tubes of different sizes made, and finally out of a large number of samples the following have been chosen as the most practical and the easiest to handle. For convenience I have had these tubes fitted to a box, which also contains directions for their

use. The tubes as seen in Diagrams III. and IV. are merely enlarged test-tubes blown into a glass standard, and having a small hole at the mouth for the entrance of air.

DIAGRAM III.

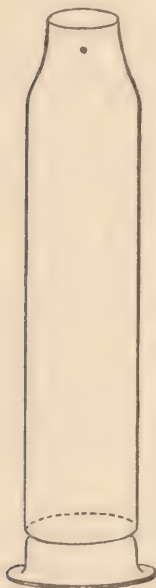


DIAGRAM IV.



A measuring-glass graduated to hold two ounces, and shaped like the larger tubes, is also in the box, and is used as a feeding-tube during the first six weeks, and later as a measure for the larger tubes. The smaller tube, Diagram IV., holds four ounces, has a calibre of one and five-eighths inches, and a height of six inches; it is to be used from the sixth week to the fifth or sixth month, and is intended to correspond to the above-described rapid growth of the stomach in the first two months, and its insignificant further increase in size up to the fifth or sixth month; it is represented in the diagram with the nipple adjusted for use. The large tube, Diagram III., has a calibre of one and six-eighths inches, a height of eight and three-fourths inches, and corresponds to the common half-pint nursing-bottle; it is represented in the diagram without the nipple, and shows the air-hole.

The box, besides the rubber nipple, contains a rubber cot

for sterilization, test-paper for ascertaining the reaction of the food, and a bottle of soda for keeping the tubes pure during the intervals of nursing.

A medium-sized tube, which does not come with the box, but can be had separately, has a calibre of one and six-eighths inches, a height of seven and three-fourths inches, and holds six ounces. It of course is not a necessity, but is intended to be used between the sixth and tenth month, merely to enunciate the importance of careful supervision of quantity throughout the first year, as where a food qualitatively correct is being used, the error, as a rule, is in giving too great an amount quantitatively than too little, and a food which otherwise would be digested perfectly well often fails if it is given in too large an amount or at improper intervals; we may, however, here notice that while in breast-feeding frequent feeding is contraindicated from its altering the character of the food, in fact, condensing it, this trouble does not of course arise in artificial feeding, the food remaining the same, and we thus have a little more latitude given us in our management than we can have in regulating the breast-feeding.

The question of the food itself in artificial feeding is practically reduced to some modification of cow's milk or to cow's milk itself, for in most civilized communities cow's milk is far more easily obtained than other milks; and although the milk of other animals may approach more nearly the per cents. of the ingredients of human milk, they must all be modified, and if we modify at all, it is as easy to deal with cow's milk as with these other milks. Then, again, the various foods, patent or not, all depend for their basis on milk, and without this addition of milk would show but an insignificant percentage of many of the most important ingredients of the food, so that logically we should speak not of the various foods as such, but merely as adjuvants to cow's milk, for if this is thoroughly understood it will, in many minds, do away with much misapprehension regarding the apparently successful results of innumerable foods which, in reality, when given to the infant, are merely a means of modifying the almost universal representative of the artificial foods, cow's milk. Cow's milk, therefore, should be carefully compared with the standard

human milk in order that we should know how nearly it resembles it, and Table II. is a comparison of the two foods, the figures representing the later and more reliable analyses. In considering the preparation of the various foods with reference to making them correspond in their analyses as nearly as possible to human milk, the problem is somewhat simplified if we recognize the fact that although the per cents. of the ingredients of human milk vary under certain circumstances, yet so far as the age is concerned, in the early months there is so little variation that a variation is as likely to occur between different milks of the same age as the same milk at different ages, so that we probably are doing wisely not to change the per cent. of the ingredients, but as the infant grows older give a food qualitatively uniform but of varying quantity.

From the comparison, we at once see that cow's milk itself differs so markedly from human milk that it evidently should be modified before being used as a food.

It may be modified by water, or by the patent foods, or by any adjuvant, such as barley-water, lime-water, or its own cream.

There is a very large number of patent foods, but they all claim about the same advantages, and closely resemble each other in their constituents, and in their honest endeavor to make cow's milk easily digestible, and also to make their resulting analysis agree as closely as possible with human milk. There are, however, certain differences by which we can divide them into classes, and we can speak of individual foods as representing their class.

Table II.

<i>Human Milk.</i>		<i>Cow's Milk.</i>
87-88	Water.....	86-87
13-12	Total solids.....	14-13
4.	Fat.....	4.
1.	Albuminoids.....	4.
7.	Sugar.....	4.5
0.2	Ash.....	0.7
Alkaline.	Reaction.....	Acid.
Small proportionately.....	Coagulable albuminoids.....	Large proportionately.
Scarcely perceptible in test-tube. }	Coagulation by acids.....	Marked in test-tube: greatest with pure milk; least when mixed with lime- water or barley- water.
Not present.	Bacteria.....	Present.

My own opinion in regard to patent foods as a whole is that they must necessarily be unreliable; they are thrown on the market in such numbers that the competition is extreme, and when once they have made a reputation I cannot but feel that irregularities and changes, slight, perhaps, in the eyes of the makers, may unintentionally creep in and carry their analysis still further from that of the standard human milk than it was in the beginning.

Analyses show that there is a lack of uniformity from year to year, and that original claims are apparently forgotten or allowed to give way to cheaper production. A striking example of the truth of this statement is the world-wide reputation of Mellin's Food, with its printed analysis, by Dr. Leeds, showing that it contains no starch, its starch having been converted into sugar; and yet careful analyses made later by Dr. Charles Harrington, of the Harvard Medical School, show conclusively that all the starch has not been converted into sugar, and that it is present in very appreciable quantity,—perhaps, as it may be argued, not in sufficient quantity to do any harm, but, as it is claimed not to be present at all, it gives rise to an element of uncertainty. If we wish to be exact in the preparation of our food, and if we wish to introduce starch into the food, we should prefer to use a food where starch is acknowledged to exist, and can be reduced to the amount which we may deem necessary for the especial case; and yet just as the makers of Mellin's Food in good faith state that it contains no starch, while the unquestioned reputation of Dr. Harrington as a chemist proves that in certain cases at least they are mistaken, so in the patent foods which claim to contain starch in a certain percentage, that percentage may vary so much as to make any combination which we may wish to make an uncertain rather than an exact one. Besides the objections just given to these foods as a whole, it will be seen by referring to the representatives of each class as shown in Table III. (page 14), that, even taking the analysis as given by Dr. Leeds and also the percentage of the ingredients when mixed, according to the maker's direction, with cow's milk, there is a striking similarity in all of them, in that they all show a marked variation from the standard human milk.

The patent foods can practically be divided into those which are manufactured from cereals and those which are not. The first class contains the starch of the cereal unchanged or converted into sugar.

We have then, I. A cereal food with its starch unchanged, represented by Imperial Granum. II. A cereal food with its starch claimed to be converted into sugar, represented by Mellin's Food. III. A cereal mixed with condensed milk, its starch unchanged, and represented by Nestle's Food. IV. Condensed milk. V. The so-called humanized or peptonized milk.

I have prepared Table III. not only to show the ingredients of the representative foods (the analyses of the patent foods in Table III. were made by Prof. Leeds, and were published in the *Medical News* of July 21, 1883), but the ingredients of the food as it is usually given to the infant, mixed with cow's milk, and reference to this table and to the analysis of human milk on the upper line will not only show the errors of nutrition, which are made when we use them in this way, but enables us, by a simple process of calculation, to make any of them correspond more closely to the standard, for all of these foods are at times useful, provided that we use them intelligently for the especial case; but, of the foods represented in the table, we should avoid the patent foods for general use on account of the objection referred to above regarding their manufacture as a class; they are also the most difficult class of foods to make correspond to human milk.

An examination of Table III. will at once explain how difficult it is to make the artificial foods correspond to human milk by the methods which are usually employed, and also the errors in percentage which result from these methods; it is, in fact, a series of figures which represent the element of nutrition rather than digestion, and the merits of every food should be determined in this way before submitting it to the test of clinical experience, for our common sense must certainly be better satisfied if we know that the infant is not only digesting the food, but that the food itself is similar (or as nearly so as we can make it) in its proportions, ingredients, and reaction to the standard which, in its results, shows the lowest rate of mortality.

Table III.
Comparison of Human Milk with Cow's Milk and Cow's Milk Modified.

(The figures are approximate and represent general averages.)

	Reaction.	Starch.	Water.	Total Solids.	Fat.	Albuminoids.	Sugar.	Ash.
Human milk.....	Alkaline.	0	88	12	3-4	1-2	7	0.1-2
Cow's milk.....	Acid.	0	87	13	4	4	4.5	0.7
Cow's milk..... Water..... 1 2 — 3	Acid.	0	95.61	4.39	1.33	1.33	1.5	0.23
Cow's milk..... Water..... 1 2 — 2	Acid.	0	93.4	6.6	2	2	2.25	0.35
Condensed milk.....		0	23	72	10	10	50	2
Condensed milk..... Water..... 1 9 — 10	Neutral.	0	92.8	7.2	1	1	5	0.2
Condensed milk..... Water..... 1 6 — 7	Neutral.	0	89.63	10.34	1.45	1.45	7.14	0.3

It will at once be seen that no matter how cow's milk is diluted with water it cannot be made to correspond to human milk. It is well, however, to remember that clinical experience has shown that infants seem, even in the early days of life, to digest the casein well enough, provided that it is sufficiently diluted,—that is, about four times, which reduces it to one per cent., and this will be of significance when we come to prepare a food which will correspond to human milk. If, however, we reduce cow's milk so that the percentage of albuminoids is one per cent., the fat and sugar fall so far below the standard that, although the ash has the proper percentage, yet we have an acid food markedly deficient in its nutritive quality.

Condensed milk is one of the most interesting foods which we are called upon to deal with, and represents in its production, its chemistry, and its clinical results an almost perfect illustration of all that has been so far said on the subject of artificial foods: it has strong advocates and strong opponents, but a simple consideration of its vital properties will easily explain the causes of its successes and of its failures.

The process of manufacture of condensed milk sterilizes it to a certain degree, and we thus have a very important factor in its favor which does not exist in cow's milk: it is also superior to cow's milk in that when mixed with water it is, although not alkaline, still not acid, and its large percentage of cane sugar helps to avoid the occurrence of fermentation, which so readily occurs in cow's milk. In Table III. the percentage of the ingredients of condensed milk—when diluted, as it commonly is, ten times—is given, and we at once see why it is easily digested but non-nutritious, for two of its ingredients, notably the fat, are found to have fallen below the standard as represented in the upper line of the table, the ash and casein only attaining the proper percentage. The nearest approach to the standard is obtained by diluting it with six parts of water, which, as shown in the table, results in giving the proper per cent. for the albuminoids, sugar, and ash, but the fat is still much reduced, and, unless supplied in some way, we should suppose that the nutrition would suffer, and this supposition appears to be supported by clinical results. That is, clinically, condensed milk represents a food easily digested but not suffi-

ciently nutritious: the former explained by its low percentage of albuminoids and ash, its neutral reaction, its anti-ferment properties, and its proper per cent. of sugar; the latter by its great lack of fat. Among the poorer classes and in infant asylums it is a favorite food for the physician to prescribe, because the infants digest it so easily, but the testimony of those clinical observers who look beyond the temporary digestion to the subsequent nutrition of the child supports the view that condensed milk, even if we set aside the objections which, in general, arise from its being a patent food, must be modified by more than the addition of water before it can safely be given as a continuous food to the average infant. For preparing the way for other more nutritious foods in cases of difficult digestion, for convenience in travelling, and where for any reason the intelligence or the proper desire to take trouble about the food is lacking in the parents, condensed milk, from its simplicity in preparation as well as from its other attributes mentioned above, is a valuable addition to other more rational methods of artificial feeding. The commonly accepted opinion that condensed milk contains too much sugar is an error, for by referring to the table it will be seen that, as usually given, the sugar in the mixture is below the proper percentage, but if it is diluted six times, as recommended above, we then have merely the fat to deal with, and the reaction, which should be made alkaline. We must, then, modify this condensed-milk mixture; and not only is the fat an important factor in this modification, but the proper amount of fat: for although it is admitted that a large per cent. of surplus fat is frequently found in the napkins of infants whose digestion and nutrition are normal, and whose food is breast-milk, yet we have no right to conclude from this that a small per cent. of fat is sufficient for nutrition or that a large per cent. will be taken care of by this outlet; in fact, it is far more probable that nature introduces a certain per cent. of fat in human milk with a purpose which can only be accomplished by that per cent., and that it is an error to vary this per cent. beyond the variation which commonly occurs in average human milk. From what has been said above we would naturally expect that unless the standard per cent. was attained, or at least a near approach to it, trouble

would be likely to arise, and this corresponds to my individual experience in the cases where the especial ingredient which was disturbing the success of the food was the fat : for I have found clinically that under the proper per cent. of fat the nutrition suffers, and that where the fat percentage was decidedly above the standard both nutrition and digestion were affected unfavorably. Unless, then, it is impossible to be more exact in arranging the percentage of fat in condensed milk, as is often the case among the poorer classes, where cod-liver oil is used as a cheap expedient for rectifying this source of error, the addition of indefinite amounts of fat to a food is to be deprecated, just as it is unwise to add indefinite amounts of sugar, and we should seek for a better combination than is offered to us in condensed milk.

Any food which introduces an element foreign to the ingredients of human milk is to be looked upon with suspicion, as it is not likely that we can improve on nature's method of adapting the food to the infant's digestive functions; we should therefore consider carefully before recommending the various classes of food which contain starch, which by referring to Table III. will be seen to be the foreign element which enters into the representative patent foods, Imperial Granum, Mellin's Food, and Nestle's Food.

It of course is not merely necessary to know the percentage of the different ingredients as they exist in the food itself, for what concerns us is the percentage as given to the infant, and the table therefore shows the sum totals of the milk percentages and the food percentages, and a glance at these figures tells us whether we have an easily digestible and nutritious food to deal with.

For instance, the success of Imperial Granum is evidently in its correct percentage of albuminoids and ash making it easily digestible, but its failures are readily explained by its reaction, its foreign ingredient, and its very low percentage of fat and sugar.

Reference has been made above to the capability shown by even very young infants to digest the casein of cow's milk when it is reduced to one or two per cent., and this is a factor which probably enters to a greater degree than is usually

recognized in the easy digestion of these foods, and possibly too much credit has been given to the starch as a means of making the casein more digestible.

This was suggested by Dr. Arthur V. Meigs some years ago, and is worth considering, as it certainly is more rational not to introduce a foreign ingredient like starch into the food if we can make it digestible in some other way. Examining this question of casein percentage in the three large classes of patent foods represented in Table III., we find Imperial Granum 1.64, Mellin's Food 2.17, and Nestle's Food .74. Now all these correspond very closely to the casein percentage of human milk, that of Mellin's Food perhaps being rather high, and all these foods are found to be easily digestible; so also where barley-water is mixed in the usual way with milk, one to two, the casein of the resulting mixture is notably diminished in amount and naturally is more easily digested than when it stands at a higher per cent., as it does in cow's milk undiluted. The fat and sugar also are very notably diminished in all these mixtures. We therefore find from the table that there is a decided failure to fulfil the factor of nutrition when cow's milk is modified with these foods, and that all of them need still further modifications, some in one ingredient and some in another, that they all contain a foreign ingredient, and all, when mixed and prepared for use, fail in that important requisite for at least the early months of life, an alkaline reaction.

There are, of course, many other foods which might be spoken of, but they all come under one or the other classifications above referred to. It may be well, however, to say a few words about peptonized milk. This is cow's milk with its casein partially or entirely predigested by means of the extract of pancreas and soda. Now there is no doubt but that the casein of cow's milk has been a source of trouble to the infant's digestive apparatus, and under certain circumstances can, with great benefit to the infant's digestion, be treated by predigesting it for a time and thus allowing a stomach, which otherwise digests well, to rest and recover itself. It is of use, also, where a decided idiosyncrasy of the individual precludes the digestion of this especial ingredient of the milk; but besides the probability that the indigestion is often attributed to

the lack of power to digest casein at all, while in fact the stomach is simply rebelling against an amount of casein above the standard per cent. or against some of the many other factors of the problem, it would seem that for the average infant digestion this predigesting of the casein or any other constituent of the milk is contrary to nature's teaching. There are certain natural functions which should be allowed to act as they do on human milk, and it seems irrational and contrary to the laws of physiology not to encourage all the functions to act naturally, each in its own province, instead of forestalling their action and allowing them to fall into disuse and thus be weakened. The baby's stomach is intended to digest casein, and not to have the casein digested for it. Clinically, also, the use of peptonized milk supports this view, for, so far as I know, no very brilliant results have been obtained from its use. Peptonized milk, then, is a food consisting of too large an amount of digested casein, too little sugar, and a very large over-proportion of ash.

The question next arises as to whether cow's milk can be modified without the use of patent foods or foreign ingredients and made to correspond to the percentages given in the upper line of Table III. This has been accomplished, with more or less success, by the addition of fat in the form of cream and by alkalies. It seems to me, however, that unqualified credit should be given to Dr. Arthur V. Meigs, of Philadelphia, not merely for devising the mixture which will be spoken of presently, for any good mathematician and chemist could have done that, but for carrying out the principle which it has been one of the chief objects of this paper to inculcate,—namely, to prepare the food free from foreign ingredients and, by chemically altering the constituents of cow's milk and especially reducing the casein to one per cent., to clinically adapt the food to the average infant's digestion. Common herd cow's milk can be diluted until the casein is reduced to one per cent., the reduced fat is then raised again to the standard by the addition of cream of a known per cent., and the sugar is also brought up to the per cent. found in human milk by means of sugar of milk. The ash is reduced to the proper per cent. at the same time that the casein is, for if we

divide the average per cent. of albuminoids and of ash in cow's milk by four, we obtain the per cents. of albuminoids and ash as they are found in average human breast-milk.

It will be noticed that the figures in Table III. give the per cent. of the ash as a whole, although we know that a number of different ingredients make up the analysis of this portion of the milk. In the future, chemistry will in all probability give us exact data regarding this analysis of the ash, and we can then by computation make a corresponding combination in the artificial food. At present, however, we are forced from want of sufficiently accurate knowledge on this point to compute the ash as a whole. Empirically, Dr. Meigs has shown that by combining two parts of cream containing from fourteen to sixteen per cent. of fat, one part average milk, two parts lime-water, and three parts sugar-water, the latter consisting of seventeen and three-fourths drachms of milk-sugar dissolved in one pint of water, we have an alkaline mixture with the percentage of its ingredients closely corresponding to that of human milk.

The figures in Table III. are the result of an analysis made by Dr. Charles Harrington of a mixture made as directed above, and the similarity to the figures in the upper line of the table representing the analysis of human milk is very striking. A number of analyses have been made for me by Dr. Harrington at different times and with different creams, and they have all corresponded closely to this one, provided that an analysis of the cream was first made in order that the proper per cent. of fat should be added to the mixture.

To avoid the necessity of having the cream analyzed, cream made by the centrifugal process can be used, for this has a per cent. which varies very little from thirty-two, so that by diluting this cream with water one-half we have a cream with a per cent. of about sixteen, which is what is usually needed for the average infant digestion.

It is possible, then, in artificial feeding, to approach the standard human breast-milk much more nearly than is usually attempted, and there is no reason why clinical results should not be much improved if physicians will only take additional time and trouble to follow more uniformly nature's teaching.

In all classes of life a much greater amount of time, expense, and thought is given proportionately to the preparation of food for the adults of the family than for the infants, and this is a mistake both from a humanitarian and an economical point of view, for the infant is much more susceptible to irregularities of diet, with their resulting suffering, than the adult, and when once the train of symptoms usually called dyspeptic is established, infinitely more trouble and expense is entailed than if more exact methods of feeding were adopted before the digestion has been tampered with. In the early weeks of lactation, after the mammary function has been fully established, it is well to have a number of analyses made of the mother's milk, and to keep the results as a control record to act as a guide for the preparation of an artificial food in case, as so frequently happens, something should occur to end the nursing at an early period, for it is highly probable that the digestive function of the individual infant may have certain idiosyncrasies which correspond to some idiosyncrasy in the percentages of its mother's milk, and in cases of difficult digestion where the artificial food, which has been made to correspond to the analysis of average woman's milk, fails to agree, reference to this control record may accomplish the solution of the problem sooner than if we had to ascertain experimentally, by changing in turn the percentages of the different ingredients, in which ingredient the idiosyncrasy of this especial infant was to be found. The assistance of the skilled chemist is too little sought after in determining these questions of infantile digestion and nutrition, and in the future must necessarily be made use of if there is to be any advance for the better in this subject of artificial feeding.

Many instructive cases could be cited, and must occur in the practice of every physician, illustrating the importance of not omitting the careful regulation of every factor of the problem, when we attempt to substitute an artificial food for the natural method of feeding, and proving that no one factor can be given undue prominence at the expense of the others, without in some way causing disturbance to the digestion and general nutrition. Making the food alkaline will at times rectify an

otherwise intractable digestion: again, as in a case of Dr. Ernst's, sterilization was the only change that was needed.

I have a number of cases showing the importance of a precise regulation of the fat percentage, and also of the sugar and the casein, while, many times, the food, although chemically correct, has proved a failure because it was given in improper quantity or at irregular intervals.

Where an infant, then, is to be fed with artificial food, give precise directions as to the times of feeding, the amount at each feeding, and the feeding apparatus which is to be used. See that the analysis of the food corresponds as closely as possible to that of human milk; give instructions as to the proper temperature of the food; see that the reaction is alkaline, and then if there is any difficulty with the digestion, sterilize the food. If this is not successful, refer to the control record and adapt the food to any maternal idiosyncrasy shown by this record. If no control record has been kept, experimentally try to discover the especial idiosyncrasy of the individual infant by changing the per cent. of the fat, sugar, casein, or ash.

